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Cost and CO_2 reduction potential in implementation of app controlled charging of electrical vehicles in a Danish Smart Grid

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Electrical vehicles in connection with an electric Smart Grid in Denmark have been proposed as a possible way to reduce the use of fossil fuel in the transport sector and utilize the energy from wind turbines in periods with low electricity demand. The aim of this study is to asses the potential of using electrical vehicles as energy storage in Denmark. Furthermore the study tries to evaluate the influence of incorporating incentives for consumers to switch from internal combustion vehicles to electrical vehicles by introducing an app for user control of vehicle charging.

The idea of a Smart Grid is to make different appliances use electricity when it is most suitable and efficient with regard to price and fluctuations in both production and demand. A way to achieve this is to store e.g. the surplus energy from the wind turbines when their production is high and the demand for electricity is lower by charging the batteries of electrical vehicles. When the demand for electricity increases at a later instant the batteries are discharged delivering electricity back to the grid.

To asses the potential in a Smart Grid in Denmark a linear model of the system is formulated in order to optimize the operation of power producing units and charging/discharging of electrical vehicles. The model is formulated based on empirical determined driving patterns, power plant specifications and operation costs, and several constraints with respect to production limits, availability of cars, buffer levels etc.

In connection with simulation of the model the functional design and requirements to a smart phone app is made to take the irregular driving demands required from users into account. The results are compared to the results obtained assuming regular predictive driving patterns.

Assuming the entire car fleet of personal cars in Denmark is switched to electrical vehicles with a predictive driving pattern the model results show that the weekly production cost of electricity increases from approximately 23 mill. € to 30 mill. € - a rise of 7 mill. € per week. However, the switch from internal combustion engines vehicles to electrical vehicles reduces the use of gasoline to zero which represents a cost saving for consumers and hence society of 55 mill. € per week. The corresponding CO_2 emission associated with electricity production increases with 90,000 tonne per week. The reduction in CO_2 emission associated with substitution of the gasoline fuel with electric power is approximately 135,000 tonne per week. Thus, the net CO_2 emission reduction is around 45,000 tonne or 33% of the emission associated with passenger car transportation.

If not all passenger cars, but only one car in families with two cars is switched to electrical vehicles, and if more app controlled user flexibility is implemented in the model the cost savings and emission reductions are decreased, but still the outcome is favorable for the society and more sustainable than practice of today.